

# The Oregon Promise population: the search for barley contributions to beer flavor leads to unexpected opportunities

P.M. Hayes<sup>1</sup>, D. Carey<sup>2</sup>, L. Cistue<sup>3</sup>, B. Echávarri<sup>3</sup>, T. Filichkin<sup>1</sup>, S. Fisk<sup>1</sup>, P. Green<sup>4</sup>, L. Helgerson<sup>1</sup>, C. Henson<sup>5</sup>, D. Herb<sup>1</sup>, H. Hisano<sup>6</sup>, R. Jennings<sup>7</sup>, P. Kramer<sup>7</sup>, V. Krishnan<sup>8</sup>, J. Logan<sup>8</sup>, C. Martens<sup>5</sup>, B. Meints<sup>9</sup>, M. Moscou<sup>4</sup>, K. Sato<sup>6</sup>, D. See<sup>8</sup>, R. Thiel<sup>2</sup>, W. Thomas<sup>10</sup>

<sup>1</sup> Dept. Crop and Soil Science, Oregon State University, Corvallis, OR, USA; <sup>2</sup> New Glarus Brewing, New Glarus, WI, USA; <sup>3</sup> CISC-EEAD, Zaragoza, Spain; <sup>4</sup> The Sainsbury Laboratory, John Innes Institute, Norwich, UK; <sup>5</sup> USDA-ARS Cereal Crops Research Unit, Madison, WI, USA; <sup>6</sup> Institute of Plant Science and Resources, Okayama University, Kurashiki, Japan; <sup>7</sup> Rahr Malting Co. Shakopee, MN, USA; <sup>8</sup> Dept. Plant Pathology, Washington State University, Pullman, WA, USA; <sup>9</sup> Dept. Crop and Soil Sciences, Washington State University, Mt. Vernon, WA, USA; <sup>10</sup> James Hutton Institute, Invergowrie, Dundee, Scotland, UK



## Germplasm

- 200 doubled haploids
- Selected subsets

## Genotypic data

- BOPA SNPs
- RNA-seq SNPs
- GBS

## Golden Promise x Full Pint

### Phenotypic data

Completed (*or in progress*). CCRU = USDA, ARS Cereal Crops Research Unit; New Glarus = New Glarus Brewing; OSU = Oregon State University; Rahr = Rahr Malting; IPSR = Institute of Plant Science and Resources.

Harvest Year	N =	Locations	Plot Type	Agronomics	Disease Resistance	Morphology Phenology	Malt	Malt Analysis	Beer Sensory	Beer GC-MS
2013	200 + parents	1	Single row OSU		Stripe rust	Height, heading, spike traits	Micro CCRU	Micro CCRU		
2014	200 + parents	1	Replicated yield trial OSU	All	Stripe rust Leaf rust	Height, heading, spike traits	Micro CCRU		Nano OSU	
2014	48 + parents	1	Replicated yield trial OSU	All			Micro CCRU	Micro CCRU	Nano New Glarus	
2015	200 + parents	2	Single row OSU, WSU		Stripe rust Leaf Rust Powdery Mildew	Height, heading, spike traits				
2015	48 + parents	3	Replicated yield trial OSU	All			Micro Rahr	Micro Rahr	Nano Rahr	Nano Rahr
2016	200 + parents	1	Single row WSU		Leaf Rust	Height, heading				
2016	23 + parents	3	Replicated yield trial OSU WSU	All		Height, heading	Micro CCRU	Micro CCRU	Nano OSU	TBD
2016	4 + Full Pint	1	Drill strips OSU	All			Mini/Maxi	OSU	Pilot Flavor 7	TBD
2016	3 + parents	1	Tissue culture, pot culture IPSR			Transformation efficiency				

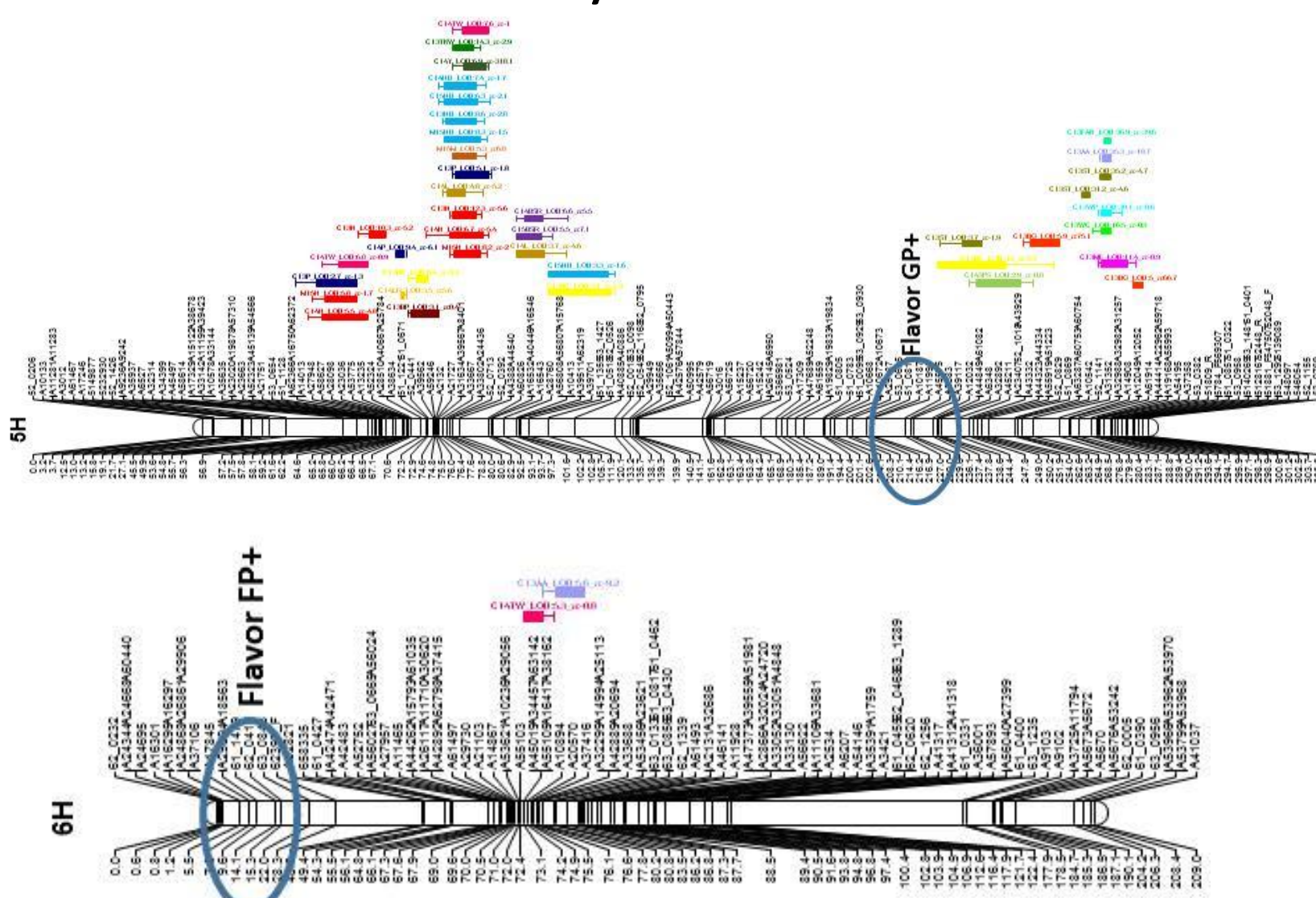
Beer sensory (New Glarus Brewing), Malting Quality (Cereal Crops Research Unit) and Agronomic (Oregon State University Barley Project) data on a sample of "Oregon Promise" doubled haploids derived from the cross of Golden Promise x Full Pint. 2014 crop, Corvallis, OR.

Barley genotype	Sensory Description	Plump (6/64")	Malt extract (%)	Wort Color (°L)	S/T (%)	Diastatic power (°ASBC)	FAN (ppm)	Yield (Kg/Ha)	Heading date (> January 1)	Dwarfing gene <sup>a</sup>	Barley stripe rust (%)	Leaf rust (%)	Subset
120031	Full, Malty, Smooth, Rich, Nice! - Best "Euro" Type	97	80	3	41	120	240	4337	142	p	20	0	Agronomic
120058	Nice Foam, Clean, Smooth - Best "American" Type	97	81	2	43	133	190	4737	146	p	0	3	Agronomic
120089	Darkest, Malty, Bready, Very Nice but Slight Grainy	98	82	2	51	93	246	4402	146	t	10	20	Agronomic
120090	Best Foam, Sweet, Clean, Mild	97	78	2	31	143	180	4702	140	e	13	8	Agronomic
120145	Balanced Malty and Hoppy, Clean, Sweet	97	80	2	41	101	177	5672	151	p	0	0	Agronomic
120156	Thin, Weak, Astringent	97	79	2	32	93	142	6111	145	e	8	0	Agronomic
120185	Grainy, sulfur, mild, sweet / dry	85	81	3	51	137	262	5108	141	d	25	45	Random
120314	Sulfur, soap, bitter, thin	96	80	3	50	96	253	4248	138	e	25	8	Agronomic
120322	Malty, sweet / dry, morish, low color	98	79	2	37	134	167	6032	138	t	23	5	Random
120330	Malty, middle of the road, slight fruity	99	79	2	34	120	146	5054	143	t	3	3	Agronomic
120331	Light, clean, malty, sulfur, Euro, juicy, nice	98	80	2	31	104	135	5323	138	e	13	3	Agronomic
120338	Grainy, harsh, low color, DMS	68	78	2	35	99	133	5464	145	d	0	38	Random
120342	Nice foam, full, bitter, sulfur	91	80	2	44	120	230	5178	139	e	30	8	Random
120359	Wow, malty, biscuit, sweet, candy, floral	64	78	2	33	105	134	5801	145	d	20	40	Random
120366	Malty, sulfur, neutral, slight harsh	96	81	2	45	115	217	4940	144	e	10	5	Agronomic
120373	Coffee! Roasted bitter, "White Stout"?, very unique	79	81	2	51	106	230	7061	139	e	23	50	Random
120381	Sulfur, neutral, harsh	97	80	2	44	120	191	5933	141	e	25	5	Agronomic
120384	Biscuit, sulfur, sweet, clean but slight bite	97	80	2	33	91	131	7184	148	p	3	3	Agronomic
120516	Grainy, husky, biscuit, honey	96	80	2	37	162	195	6276	147	p	23	0	Agronomic
120521	Neutral, bland	96	77	2	33	104	165	5652	147	p	0	8	Agronomic
120691	Malty but too sweet	98	79	2	43	116	205	4787	146	p	0	3	Agronomic
120715	Flour, cereal	94	81	2	34	103	124	5858	148	p	10	0	Agronomic
120731	Smooth, hoppy, American, sweet	93	81	2	37	99	155	5613	143	?	3	5	Agronomic
120744	Malty, bread, European, very nice	90	81	2	46	102	207	6215	142	?	0	3	Random
Full Pint	Full, malty, European	88	80	2	35	83	128	6533	143	p	8	0	Parent
Golden Promise	Harsh bitterness	98	81	3	47	146	220	6937	143	e	3	23	Parent

<sup>a</sup> t=tall (no dwarf allele), e= ari-e.GP semi-dwarf allele, p= sdw1 semi-dwarf allele, d= ari-e.GP and sdw1 semi-dwarf alleles

QTLs for key traits from the full population and flavor  
QTLs for New Glarus sensory based on a subset

### QTLs



- AA=Alpha Amylase
- B=Brackling
- BC=Barley Color
- BG=Beta-glucan
- BP=Barley Protein
- BSR=Barley Stripe Rust
- DP=Diastatic Power
- FAN=Free Amino Nitrogen
- H=Height
- HD=Heading Date
- HE=Head Emergence
- L=Lodging
- LR=Leaf Rust
- M=Mildew
- ME=Malt Extract
- P=Plump
- SL=Spike Length
- SPS=Seeds per Spike
- ST=Soluble/Total Nitrogen
- SW=Spike Weight
- TKW=Thousand Kernel Weight
- TW=Test Weight
- WC=Wort Color
- Y=Yield

### Acknowledgements:

Financial support for research provided by:

- At OSU: The Flavor 7-pack of breweries: Bells, Deschutes, Firestone Walker, New Glarus, Russian River, Sierra Nevada, and Summit.
- At CISC-EEAD: Spanish Ministry of Science and Innovation (project AGL2015-69435-C3-2-R).
- At IPSR: JSPS KAKENHI, grant numbers 24880025 and 16K18634 to HH.

Oregon Promise logo design: Seth Klann